Commercial Unitary Air Conditioner and Heat Pump Rulemaking Framework

U.S. Department of Energy
Office of Codes and Standards
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1. Introduction

The purpose of this document is to describe the procedural and analytical approaches the U.S. Department of Energy (hereafter called the Department or DOE) anticipates using to evaluate whether amended standards should be developed that are more stringent than standards found in American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) / Illuminating Engineering Society of North America (IESNA) Standard 90.1 - 1999 (ASHRAE/IESNA Standard 90.1-1999) for commercial unitary air-conditioners and heat pumps. As described in more detail below, the procedure for developing amended energy conservation standards entails several rounds of analysis and multiple consultations with interested stakeholders. This document is intended to inform and facilitate stakeholders' involvement in the rulemaking process. Section 1 provides an overview of the process. Sections 2 through 16 discuss analyses to be done. Information regarding the commercial unitary air-conditioner (AC) and heat pump (HP) rulemaking will be maintained on the DOE website at

http://www.eren.doe.gov/buildings/codes_standards/index.htm

In addition to the general discussion presented within its main text, this document contains comment boxes, like this one, that address issues specific to the application of the analytical framework to the commercial unitary air AC and HP rule. These boxes follow a generic description of each component of a typical rulemaking, and include a discussion of key issues, the Department's perspectives on these issues, and requests for additional stakeholder input.

1.1 Commercial Equipment Efficiency Program

The Energy Policy and Conservation Act (EPCA) of 1975, Pub. L. 94-163, established an energy conservation program for major household appliances. The National Energy Conservation Policy Act of 1978, (NECPA) Pub. L. 95-619, amended EPCA to add Part C of Title III, which established an energy conservation program for certain industrial equipment. The amendments to EPCA in the Energy Policy Act of 1992 (EPACT), Pub. L.. 102-486, included amendments that expanded DOE's energy conservation program to include certain commercial equipment, including unitary air-conditioners and heat pumps, the focus of this document.

The efficiency requirements in the statute correspond to the levels in ASHRAE/IESNA Standard 90.1 as in effect on October 24, 1992. The statute further provides that if the efficiency levels in ASHRAE/IESNA Standard 90.1 are amended after that date for any of the covered products, the Secretary of Energy (Secretary) must establish an amended uniform national standard for such equipment at the new minimum level for each effective date specified in ASHRAE/IESNA Standard 90.1, unless (s)he determines, through a rulemaking supported by clear and convincing evidence, that a more stringent standard is technologically feasible and economically justified and would result in significant additional energy conservation. EPCA section 342 (a)(6)(A), 42 U.S.C. 6313 (a)(6)(A).

Under EPCA, if DOE adopts a more stringent standard, it must consider, to the greatest extent practicable, the economic impact of the standard on the manufacturers and consumers of the affected products; the savings in operating costs throughout the estimated average life of the product compared to any increases in the initial cost, or maintenance expense; the total projected amount of energy savings likely to result directly from the imposition of the standard; any lessening of the utility or the performance of the products likely to result from the imposition of the standard; the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard; the need for national energy conservation; and other factors the Secretary considers relevant. EPCA section 342 (a)(6)(B)(i), 42 U.S.C. 6313(a)(6)(B)(i). Other statutory requirements are set forth in EPCA section 342 (6)(B)(ii) and (C).

On October 29, 1999, ASHRAE/IESNA adopted Standard 90.1-1999 which includes certain revisions to efficiency levels for covered products, including unitary air-conditioners and heat pumps. DOE conducted a screening analysis and on that basis determined that further analysis under a formal rulemaking process was warranted for unitary air-conditioners and heat pumps.

As the analysis under this rulemaking proceeds, DOE intends to make its findings available to the Standard 90.1 committee and other stakeholders for the purpose of informing ASHRAE's "continuous maintenance" addenda process. Furthermore, DOE may choose to propose an addendum to ASHRAE/IESNA Standard 90.1-1999.

DOE may also choose to proceed with adopting ASHRAE/IESNA Standard 90.1-1999 levels for these products whenever DOE concludes that the EPCA criteria for a more stringent standard are not likely to be satisfied. This could occur either as a result of further analysis by DOE during the rulemaking process or by ASHRAE adopting a new addendum to ASHRAE/IESNA Standard 90.1-1999 for which a more stringent alternative is not justified.

The Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Building Research and Standards (BRS) conducts the program that develops and promulgates equipment energy conservation standards and has overall responsibility for rulemaking activities for unitary air-conditioners and heat pumps. The Department has contracts with Lawrence Berkeley National Laboratory (LBNL), Arthur D. Little, Inc. (ADL), and Pacific Northwest National Laboratory (PNNL) to provide technical, analytical and managerial support in conducting these activities.

As defined by EPCA, the term "small commercial package air conditioning and heating equipment" means air-cooled, water-cooled, evaporatively-cooled, or water source (not including ground water source) electrically operated, unitary central AC and central air conditioning HPs for commercial application which are rated below 135,000 Btu per hour (cooling capacity). The term "large commercial package air conditioning and heating equipment" means air-cooled, water-cooled, evaporatively cooled or water source (not including ground water source) electrically operated, unitary central AC and central air conditioning HPs for commercial application which are rated at or above 135,000 Btu per hour and below 240,00 Btu per hour (cooling capacity). See EPCA sections 340 (8) and (9), 42 U.S.C. 6311 (8) and (9).

The term "unitary air conditioner" means air-cooled, electrically operated unitary air conditioners for commercial application which are rated between 65 and 135 kBtu/h ("small") or between 135 and 240 kBtu/h ("large").

The term "unitary heat pump" means a unitary air conditioner that utilizes reverse cycle refrigeration as its prime heat source and should have supplementary heat source available to builders with the choice of hot water, steam, or electric resistant heat. The same capacity range categories are used for both unitary air conditioners and heat pumps.

In this proceeding DOE will only examine commercial unitary AC and HP equipment that use air for cooling

Figure 1 shows DOE's time-line for amending standards for commercial unitary AC and HPs.

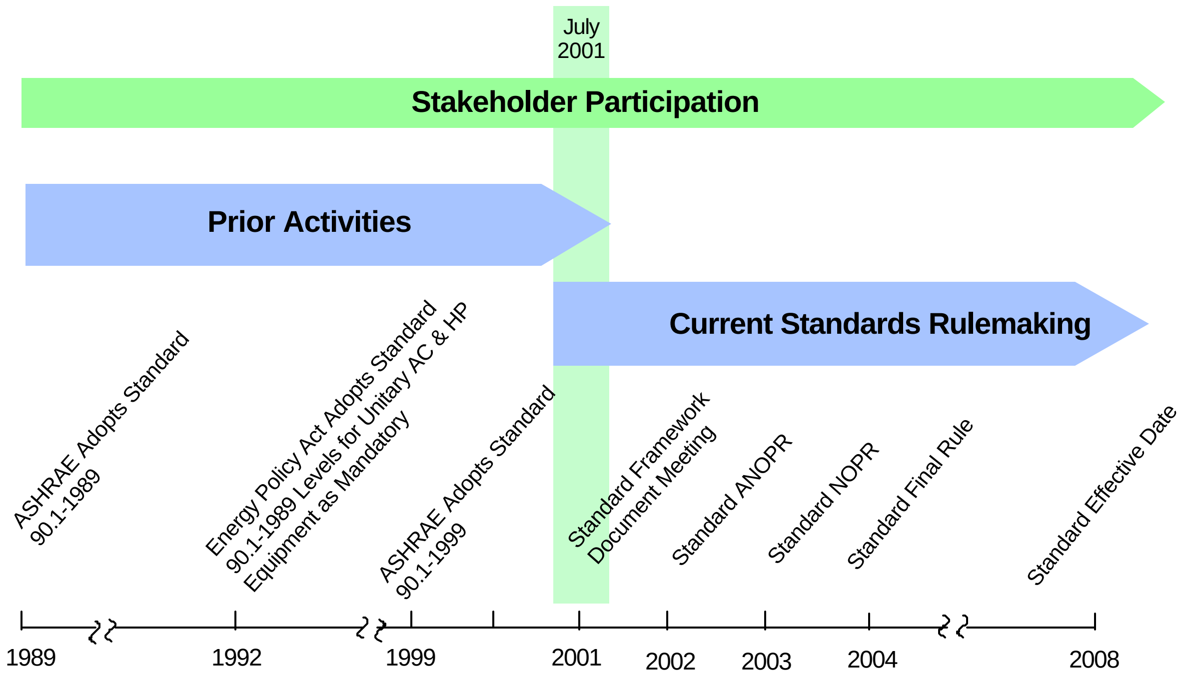


Figure 1. Principal procedural steps in the commercial unitary air-conditioner and heat pump standards setting process

1.2 Stakeholder Participation

As also indicated by Figure 1, the Department considers stakeholder participation a very important part of the process for setting energy conservation standards. The Department actively encourages the participation and interaction of all stakeholders at all stages of the process. Early and frequent interactions among stakeholders provide a balanced discussion on critical information required to conduct the analysis to support any standards.

Stakeholders include manufacturers, consumers of commercial unitary AC and HPs, energy efficiency and environmental advocates, state agencies, federal agencies and other groups or individuals with an interest in the standards.

Both the test procedures and the energy conservation standards are being developed through the rulemaking process, which involves formal public notifications that are common to the Department's rulemaking activities. For the commercial unitary AC and HP energy conservation standards rulemaking, the Department will employ the rulemaking procedures set forth in Part B of Title III of EPCA and in Appendix A to Subpart C of 10 CFR 430, "Procedures, Interpretations and Policies for Consideration of New or Revised Energy Conservation Standards for Consumer Products" (the Process Rule), (61 FR 36981, July 15, 1996), to the extent they are appropriate to develop energy conservation standards for commercial unitary AC and HP.

On March 1, 2000, the Department published a notice of preliminary screening analysis to decide which of the ASHRAE/IESNA Standard 90.1-1999 standards should be adopted immediately and which to analyze further. 65 FR 10984. On January 12, 2001, the Department published a final rule adopting the ASHRAE/IESNA Standard 90.1-1999 level for 18 product categories and made a decision to further evaluate other products. 66 FR 3336. In the final rule, DOE determined that further analysis was warranted for commercial unitary air conditioners and heat pumps. This conclusion was based on DOE's screening analysis. The Department is considering more stringent standards then those adopted by ASHRAE/IESNA Standard 90.1-1999.

The test procedure development for commercial unitary AC and HP was initiated on April 14 and 15, 1998, when the Department held a public workshop to solicit views and information from interested parties. The Department convened a second public workshop on October 18, 1998. The Department published a NOPR on August 9, 2000 and held a public hearing on September 21, 2000. 65 FR 48828. The Department expects to publish the test procedure final rule before publishing the ANOPR on energy conservation standards.

In an energy conservation standards rulemaking, the first of the rulemaking notices is an Advance Notice of Proposed Rulemaking (ANOPR), which is designed to facilitate extensive and early public participation and to select candidate standard levels for further analyses. The ANOPR is followed by the publication of a Notice of Proposed Rulemaking (NOPR) which will propose energy conservation standards. The completion of the rulemaking process is a Notice of Final Rulemaking which places the energy conservation standards in the Code of Federal Regulations.

The process provides numerous opportunities for stakeholder involvement. Specifically, the Department intends to request public comments on the ANOPR, with a 75-day public comment period and at least one public hearing or workshop, and public comments on the NOPR, with a 75-day public comment period and at least one public hearing or workshop. These activities will be summarized and published in rulemaking notices that appear in the Federal Register and on the Department's website. Technical Support Documents (TSD) also will be prepared in conjunction with the notices and distributed for stakeholder review and comment in conjunction with publication of those notices.

In addition, the Department will elicit stakeholder participation prior to these notices and during analyses prepared in support of the notices. The first of these opportunities will be the framework meeting to discuss the information contained in this document, and the Department will also seek written comments on this document.

The formal rulemaking process for development of energy conservation standards includes three notices: the ANOPR (see Section 1.3 below), the NOPR (see Section 1.4 below), and the Notice of Final Rulemaking (see Section 1.5 below). The activities that are relevant to the development of energy conservation standards for commercial unitary AC and HP leading to each of these notices and the relationships among them are described below.

1.3 Advance Notice of Proposed Rulemaking

As part of its initial rulemaking activities, the Department will identify the product design options or efficiency levels that will be analyzed in detail and those that can be eliminated from further consideration. This process includes a market and technology assessment (see Section 3) and a screening analysis (see Section 4). These activities include consultations with stakeholders and independent technical experts who can assist with identifying the key issues and design options or efficiency levels to be considered.

The technologically feasible design options or efficiency levels that are not eliminated in the screening process are considered further. The principal activities undertaken during this stage are: an engineering analysis (see Section 5), a life-cycle cost and payback analysis (see Section 8), and preliminary national impact analysis (see Section 10).

The results of the analyses will be made available on the Department's website for review and the Department will consider comments on them. This review and comment process may result in revisions to the analyses. If appropriate, public workshops may be conducted to enhance the exchange of information and comments. This analytical process culminates with the selection of candidate standard levels, if any, that will be considered for the NOPR. The candidate standard levels are contained in the ANOPR which DOE publishes in the Federal Register. The ANOPR specifies the candidate standard levels that are chosen for further analysis but does not propose a particular standard. The ANOPR also presents the results of the engineering analysis and the preliminary analyses of consumer life-cycle costs, national net present value, and national energy savings. The Department will also make available a TSD containing the details of all the analyses performed to this point.

Selection of candidate standard levels is based on costs and benefits of design options or efficiency levels. Design options or efficiency levels which have payback periods that exceed the average life of the product or which cause life-cycle cost increases relative to the base case would generally not be selected as candidate standard levels.

The range of candidate standard levels will typically include:

• the most energy efficient level;
• the level with the lowest life-cycle cost; and
• candidate standard levels that incorporate noteworthy technologies or fill in large gaps between efficiency levels of other candidate standard levels.

After the publication of the ANOPR, there is a 75-day public comment period and at least one public hearing or workshop. On the basis of comments received, DOE may revise the analysis or the candidate standard levels. If major changes are required, stakeholders and technical experts will be given an opportunity to review the revised analyses.

1.4 Notice of Proposed Rulemaking

After the ANOPR, DOE will conduct further economic impact analyses of the candidate standard levels. These analyses may include refinements of the analyses done for the ANOPR and also will include: a consumer sub-group analysis (see Section 12), a manufacturer impact analysis (see Section 13), a utility impact analysis (see Section 14), an environmental analysis (see Section 15), and employment impacts (see Section 16).

The results of all the analyses will be made available on the Department's website for review and the Department will consider comments on them. This review and comment process may result in revisions to the analyses. If appropriate, public workshops may be conducted to enhance the exchange of information and comments. This analytical process culminates with the selection of proposed standard levels, if any, that will be presented in the NOPR. The NOPR, published in the Federal Register, will document the evaluation and selection of any proposed standards. For each product class, the Department also will identify the maximum improvement in energy efficiency or maximum reduction in energy use that is technologically feasible and, if the proposed standards would not achieve these levels, the Department will identify the reasons for proposing different standards. The NOPR also will present the results of all the analyses. The Department will also make available a TSD containing the details of all the analyses.

The Department considers many factors in selecting proposed standards. These factors include the selection policies established by statute and the many benefits, costs and impacts of the standards shown by the analyses. Additionally, the Department encourages stakeholders to develop joint recommendations for standard levels. If the Department receives a joint recommendation from a representative group of stakeholders, such a recommendation will be strongly considered in the decision process to select the proposed standard level.

The NOPR is followed by a 75-day public comment period that includes at least one public hearing or workshop; revisions to the analyses may result from the public comments. On the basis of the public comments, DOE reviews the proposed standard and impact analyses and makes modifications as necessary. If major changes to the analyses are required at this stage, stakeholders and experts will be given an opportunity to review the revised analyses.

1.5 Notice of Final Rulemaking

The final step in the rulemaking process would be the publication of a Notice of Final Rulemaking in the Federal Register. The Final Notice promulgates standard levels based on the record and explains the basis for the selection of those standards. It is accompanied by the final TSD.

2. Analyses for Rulemaking

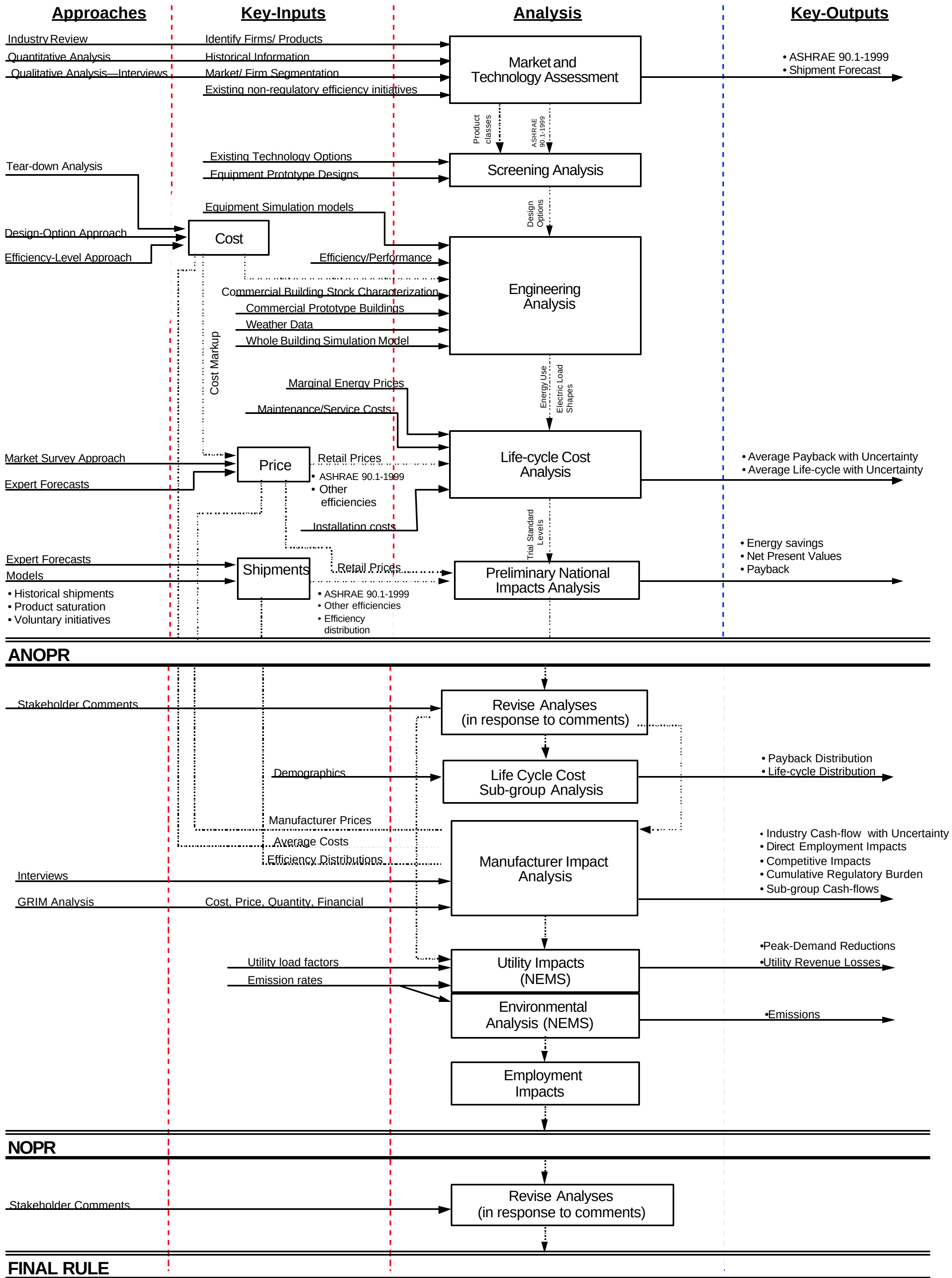
This section provides a brief description of the analyses to be conducted during the standards setting process to determine the impacts of possible standards. It offers an overview of the analytic methodology and discusses the major components of the analysis. By considering the inter-relationship among these components, the consistency of approach throughout the analysis is ensured.

2.1 Introduction

The analytical components of the standards setting process are summarized in Figure 2. The focus of this figure is the center column, identified as "Analysis." The column labeled “Approaches” is intended to indicate various methods to be used to obtain information needed for the key inputs. The columns labeled "Key Inputs" and "Key Outputs" are intended to indicate how the analyses fit into the rulemaking process, and how the analyses relate to each other. Key outputs are analytical results that feed directly into the standard-setting process. Dotted lines connecting analyses indicate types of information that feed from one analysis to another. Key inputs are the types of data and information that are required by the analyses. Some key inputs exist in public databases, some will be collected from stakeholders or others with special knowledge, and some of the key inputs will be developed by the project team to support the standards-setting process.

Ultimately, the Department intends to select the commercial unitary AC and HP energy conservation standards that achieve the maximum improvement in energy efficiency that is technologically feasible and economically justified. In the context of this process, economic justification includes consideration of the economic impacts on domestic commercial unitary AC and HP manufacturers and consumers, national benefits including environmental, issues of consumer utility and impacts from any lessening of competition. Many of the analyses are aimed at answering questions about these aspects of economic justification.

Figure 2: Flow Diagram of Analysis for the Commercial Unitary Air Conditioner and Unitary Heat Pump Rulemaking Process



3. Market and Technology Assessment

The Market and Technology Assessment will provide information about the commercial unitary AC and HP industry that will be used throughout the standards process, and at the outset to determine product classes, to identify potential design options or efficiency levels for each of the product classes.

3.1 Market Assessment

The Department will develop information on the present and past industry structure and market characteristics of the product(s) concerned. This activity will consist of both quantitative and qualitative efforts to assess the industry and products based on publicly available information. Issues to be addressed include: manufacturer market share and characteristics; trends in the number of firms; the financial situation of manufacturers; existing non-regulatory efficiency improvement initiatives; and trends in product characteristics and markets.

The information collected will serve as resource material to be used throughout the rulemaking. For instance, historical product shipments and prices will be used to help predict future prices and shipments. Market structure data will be particularly useful to conducting the competitive impacts analysis.

The Department has initiated a market assessment of the commercial unitary AC and unitary HP industry. Once completed, collected information will be distributed for comment.

The Department plans to conduct interviews with manufacturers following the framework workshop. These interviews will be useful in developing an industry profile by providing insights and information to help structure future analysis. While this effort involves the entire industry, the Department is interested in developing profiles of individual manufacturers to gain a better understanding of the potential impacts of standards on both individual firms and particular categories of firms.

Interview participants will be requested to identify all confidential information provided in writing and orally. Approximately two weeks following the interview, an interview summary will be provided to give participants the opportunity to confirm the accuracy and protect the confidentiality of all collected information. All the information transmitted will be considered, when appropriate, in the Department's decision-making process. However, confidential information will not be made available for the public record.

The Department requests stakeholders feedback on this market assessment approach.

3.2 Technology Assessment

Information about existing and past technology options and prototype designs will typically be used as input to determine what technologies manufacturers could utilize to attain higher energy efficiency levels. In consultation with interested parties, the Department intends to develop a list of technologies than can and should be considered in the analysis. Initially, the technologies will encompass all those considered to be technologically feasible and will serve to establish the maximum technologically feasible design.

The Department is collecting information on technologies that improve energy performance of commercial unitary AC and HPs. An initial list of technologies include:

- Evaporator and condenser coils with larger heat-exchanger area
- “Deep coil” or microchannel evaporator coils
- Low pressure-loss filters and cooling coils
- High efficiency motors
- High efficiency compressors, such as scrolls or “twin-single” technology
- Multiple compressors
- Inverter-driven, variable-speed compressors
- Thermal expansion valves (TXV)
- Electronic expansion valves
- Air-foil or backward-curved centrifugal fans
- Synchronous (toothed) belts or direct drive fans
- Inverter-driven, variable-speed indoor or condenser fan motors
- High-efficiency propeller condenser fans
- High-side solenoid valve or discharge line check-valve to minimize pressure equalization
- Heat-pipes (for high latent loads)
- Double-skin, high-albedo cabinets
- Sub-coolers
- Demand-control ventilation strategy

Are there specific technologies that should or should not be considered for commercial unitary AC and HP?

Equipment efficiency is generally expressed at full-load derived from a standard test procedure (e.g., EER). Part-load efficiency is another important equipment design parameter used by manufacturers. Equipment design options for increasing full-load performance can impact part-load performance positively or negatively. Also, part-load performance is a key factor for assessing the in-situ energy performance and energy savings of the equipment. The Department intends to assess the impact of design options on part-load performance.

Current standards for commercial unitary AC and HP are based on full load efficiency criteria (i.e.,Energy Efficiency Ratio (EER) and Coefficient of Performance (COP)) only. What are the potential drawbacks and benefits of the Department mandating only minimum full load efficiency, but not part-load efficiency in this rulemaking?

3.3 Product Classes

Products may be separated into product classes if their capacity or other performance-related features or attributes, including those that provide utility to the consumer, inherently affect efficiency and justify the establishment of a different energy conservation standard, or possible exemption form energy conservation standards for products with that feature or attribute. Such different standards would then be formulated for the different product classes. In general, classes are defined using information obtained in discussions with manufacturers, trade associations, and other interested parties.

The Department is considering the following product classes for this rulemaking:

- AC (65-135 kBtu/hr), single package and split system
- AC (135-240 kBtu/hr), single package and split system
- HP (65-135 kBtu/hr), single package and split system
- HP (135-240 kBtu/hr), single package and split system
-

Should the Department consider creating additional classes based on performance related features or other attributes?

What capacity equipment should be used in the analysis as the representative capacity for a given capacity range (e.g., 7.5 ton for 65 – 135 kBtu/hr and 15 ton for 135-240 kBtu/hr)? Should this value be the same for unitary AC and unitary HPs, or are unique values warranted? If so what should they be?

3.4. Baseline Units [1]

A baseline model is established as a reference point for each product class against which changes that would be brought about by energy conservation standards can be measured. A baseline model represents the characteristics of a commercial unitary AC and HP of a specific product class including operating capabilities energy efficiency and price. Typically a baseline model would be a model that

[1] Note that the meaning of *baseline* is distinct from the time-dynamic base case, which is used in the National Energy Savings analysis. In that analysis, the base case represents the mix of models currently on the market and, in each future year, projected to be sold in the absence of energy conservation standards.

just meets required energy conservation standards. After the product classes are chosen, the characteristics of the baseline model for each class are defined. The baseline model is used in the life-cycle cost and payback analyses. To determine energy savings and change in price, each higher efficiency design option is compared with the baseline model.

One of the most vital statistics required for establishing the baseline model is its efficiency. In this rulemaking, ASHRAE/IESNA Standard 90.1-1999 provides the minimum efficiency levels that will be used as the baseline. For these products, DOE will further evaluate whether more stringent standards than those adopted by ASHRAE/IESNA Standard 90.1-1999 are warranted.

Since EPCA 1992 energy conservation standards are the current statutory requirements, the Department may choose to use the 1992 statutory standards in selected analyses to assist in determining energy savings.

If more detailed approaches are selected for conducting the engineering analysis, such as the design options approach, manufacturers may be requested to supply details on the technologies they utilize in their baseline or minimum efficiency models. This information will assist the Department in establishing what technologies can be employed to increase the efficiency of the equipment.

The Department invites stakeholder feedback on this methodology.

4. Screening Analysis

The purpose of the screening analysis is to identify and evaluate those design options or efficiency levels that could improve commercial unitary AC and HP efficiency and to determine which to evaluate in detail in the engineering analysis and to evaluate no further during this rulemaking. This screening process includes consultations with interested parties and independent technical experts who can assist with identifying the key issues and design options or efficiency levels. The screening analysis also discuses the criteria for eliminating certain design options or efficiency levels from further consideration. By comparing the design options or efficiency levels against these criteria, the Department eliminates from further analysis those options or efficiency levels that are not sufficiently developed or have characteristics that make them technologically unsuitable for consideration in the rulemaking.

4.1 Design Options

An initial list of design options will be developed from the technologies identified in the technology assessment. Following the development of this initial list of design options, the Department, in consultation with interested parties, will review each design option to determine if it is practicable to manufacture, install and service; would adversely impact equipment utility or equipment availability; or would have adverse impacts on health and safety. Design options not eliminated in the screening process will be considered in the subsequent engineering analysis.

Compiling a list of design options will provide a better understanding about the specific technologies that may be utilized by manufacturers to improve equipment efficiency. Knowing the technologies that are available to manufacturers to increase efficiency will also help the Department determine maximum technologically feasible efficiency levels.

In developing a list of design options, the Department's primary consideration is how a technology will impact the efficiency of the equipment as measured by the EER for cooling equipment and the COP for heating equipment. A secondary consideration is how the technology will affect part-load performance such as integrated part load value (IPLV), which is derived from a standard test procedure, in addition to EER and COP.

Should the Department consider other factors in developing its list of potential design options? For example, should increases in EER be limited by the latent heat removal capability of the equipment in order to make the product suitable for high humidity areas of the country?

The Department will need to make certain assumptions about equipment design related to its capacity and capacity control. Larger capacity equipment has multiple ways of meeting the peak capacity requirements (e.g., number of compressors), which will require assumptions about how the equipment would be designed for any given capacity irrespective of the efficiency level. Commercial unitary AC and HPs may include capacity control, which may be implemented in different ways (e.g., multiple compressors, variable speed). This will impact manufacturer's strategies to increase EER in different ways.

What assumptions should the Department make regarding design for specific capacities of equipment? How should the Department address capacity control measures?

5. Engineering Analysis

After the screening analysis, the Department performs an engineering analysis on the design options or efficiency levels that were not eliminated. The engineering analysis consists of estimating the energy consumption and costs of commercial unitary AC and HPs at various levels of increased efficiency. This section discusses an overview of the engineering analysis (Section 5.1), the approaches to determining equipment efficiency (Section 5.2), the approaches to estimating costs (Section 5.3), other regulatory impacts on the engineering analysis (Section 5.4), and the analysis of energy consumption and electric load shape impacts of equipment operated in buildings (Section 5.5)

5.1 Engineering Analysis Overview

The purpose of the engineering analysis is to evaluate the increased equipment efficiency levels and associated manufacturing costs. The baseline units and possible design options are identified in the screening analysis (Section 4). The Department, in consultation with stakeholders, will use the most appropriate means available to determine energy efficiency. Ranges and uncertainties in performance will be established. The energy efficiency measures developed in the engineering analysis will be analyzed for energy savings potential in the building energy use analysis and combined with end-user costs in the life-cycle cost analysis.

The engineering analysis involves estimating the possible efficiency increases from the baseline units (described in Section 3.4). A representative baseline unit will be established for each product class that is identified. A cost-efficiency relationship will be developed to show the manufacturer cost of achieving increased efficiency.

The efficiency levels corresponding to various design option combinations will be determined from the information on products that are commercially available, data submitted by manufacturers and/or engineering calculations.

The Department is aware that the most efficient commercial unitary AC listed in the most recent version of the *ARI Unitary Directory* has an EER rating of 12.0. The most efficient HP listed has a COP of 4.0. Therefore the Department proposes to establish these as starting points to establish the upper range of energy efficiency to be covered in the analysis.

The Department is interested in comments on the range of efficiencies that should be considered.

Cost estimates for the engineering analysis (which are also used for the manufacturer impact analysis described in Section 13) will be obtained from detailed incremental cost data disaggregated into the cost of equipment components, labor, purchased parts and material, shipping/packaging and investment. Estimates of the total cost to the consumer include the retail price of equipment and energy and the installation and maintenance costs. The Department will generate manufacturing cost estimates through the use of some combination of tear-down analysis, manufacturer supplied estimates, and direct estimates of retail prices.

There are several ways to establish a relationship between cost and performance. The Department understands that a fundamental decision is whether to use the *efficiency level* or design options approach for the engineering analysis. Another decision concerns selecting from the various cost estimation methods including *tear-down* analysis and *price surveys*.

Since the availability of commercial unitary AC and HP equipment in the marketplace is not uniform across the efficiency levels under consideration, the Department may decide to combine the efficiency level and design options approaches. In this combined approach, the Department would develop a single spreadsheet and use it to represent the cost of equipment at the various efficiency levels covered by the analysis. Engineering expertise, results from simulation modeling, information gathered through tear-down analysis and manufacturer data submissions would all be used to populate the spreadsheet. Combining data sources in this way will allow the Department to represent equipment throughout the entire efficiency range without depending exclusively on simulation modeling. This approach would also limit public access to proprietary data, yet allow the public to examine the cost and design assumptions that underlie the cost-efficiency estimates.

The Department seeks input from stakeholders about pursuing a combined approach for the engineering analysis.

5.2 Approaches to Determining Efficiency Improvements

There are two methods for identifying the opportunities for increasing energy efficiency: the efficiency level approach (i.e., mix of technologies at specific efficiency levels) and design options approach (i.e., technology specific).

5.2.1 Efficiency Level Approach

The efficiency level approach establishes the relationship between manufacturer cost and increased efficiency at predetermined efficiency levels. It has the initial advantage of being simple and straight forward. Manufacturers typically provide incremental manufacturer's cost data for incremental increases in efficiency. Cost-efficiency curves can then be constructed from this data. Additionally, the efficiency level approach allows manufacturers the ability to supply cost data without revealing details of their manufacturing processes or costs.

However, the simplicity of the efficiency level approach is also its primary drawback. Namely, since technological details are not provided, it could be difficult to verify the accuracy of the cost information received from the manufacturers. The inability to verify information received would lead to greater uncertainty about the costs of efficiency improvements for commercial unitary AC and HPs. In addition, prototypical designs become difficult to evaluate and maximum technologically feasible designs are then difficult to ascertain. For example, if two manufacturers choose markedly different designs with significantly different costs to attain the same efficiency level, taking an average of the costs may not accurately represent the situation. As a result, some stakeholders may prefer to supplement the engineering analysis with additional detail which needs to be derived from other sources in order to verify the accuracy of the data supplied through the efficiency level approach.

If the efficiency level approach is selected for conducting the engineering analysis, predetermined efficiency levels will be selected by the Department based on consultations with stakeholders.

The Department seeks input from stakeholders as to how the efficiency level approach can be applied to HPs to ensure that both cooling and heating performance are taken into account.

As discussed above, the efficiency level approach requires verification of the data submitted. Other approaches, such as the design options method, can be conducted in parallel with the efficiency level approach to verify the accuracy of its data.

The Department seeks input on what methods could be utilized to verify the data provided by manufacturers using the efficiency level approach. Should the efficiency level approach be used? What are the benefits and disadvantages of this approach?

5.2.2 Design Options Approach

Under the design options approach, individual or combinations of design options are identified for increased efficiency. Design option efficiency increases can either be based on manufacturer or component supplier estimates or through the use of engineering computer simulation models. The incremental manufacturing costs of adding design options to a baseline model are then established. Individual design options or combinations of design options are added to the baseline model in ascending order of cost-effectiveness. Typically, the consumer payback period is used to establish a design option's cost-effectiveness and is determined by the ratio of the change in total installed cost to the change in operating cost (both as compared to the baseline).

The strength of this approach is in gaining a better understanding of the technological and economic basis of efficiency improvements. Through the design options approach we have the ability to analyze individual technologies and to combine them in sequence. The approach is transparent in that the impact of any single technology on cost and efficiency is explicit. An additional advantage is the ability to incorporate designs that have been demonstrated to perform in prototypes but have yet to be utilized in equipment currently available on the market. Thus, maximum technologically feasible designs are more easily established than in the efficiency level approach.

Although individual technologies can be assessed, the design options approach can be complex. If individual technologies (especially prototype designs) are combined in ways not typically utilized by manufacturers, attention must be paid to the overall system cost and efficiency. In order to determine a technology's impact on system efficiency, a computer simulation model is typically employed. Since computer simulation models exhibit at least some level of inaccuracy, time and effort must be expended to validate the model's results at a variety of operating conditions. Equipment simulation models may demand detailed input balanced by the need to protect manufacturers and component suppliers proprietary design strategies. Also, equipment performance data at specified test conditions must be supplied in order to validate the model's performance.

The design options approach must be reconciled with the manufacturing impact analysis. The Department recognizes that the manufacturer cost information derived in a component-based analysis should reflect the variability in baseline units, design strategies and cost structures that can exist among manufacturers, in order to be most useful in the manufacturing impact analysis. Therefore, for the manufacturing impact analysis, the Department may need to derive additional manufacturing cost estimates, using other approaches developed in consultation with interested parties.

If the design options approach is used for the engineering analysis, methods will have to be established for determining efficiency increases. As stated above, this can be done either directly through stakeholder input or through the use of computer simulation models. There are at least two public domain computer models for unitary AC and HPs, one from Oak Ridge National Laboratory and the other from the National Institute of Standards and Technology, which could be used to determine equipment efficiency.

The Department seeks input from stakeholders as to how efficiency impacts could be determined under the design options approach. If computer simulation models are to be used, which specific model should be used by the Department? Should the design options approach be used? What are the benefits and disadvantages of this approach?

5.3 Approaches to Determining Cost Estimates

The Department strongly prefers to use a single set of cost-efficiency estimates in its analysis, and to account for variability and uncertainty by using ranges, rather than analyzing competing scenarios. Stakeholders are welcome to submit their own estimates in the form of public comment, but the Department intends to analyze the differences among independent estimates and to synthesize them into a range along with a most likely value. The cost estimates used should have the following characteristics:

- a level of transparency that permits validation by outside parties;
- a level of detail that permits outside parties to draw conclusions regarding the design choices underlying the analysis;
- protection of sensitive or confidential information;
- a basis of generally accepted cost and performance estimation methodologies;
- an assessable level of statistical certainty; and
- be available by the scheduled deadline.

To the extent possible, the Department will seek the involvement of outside experts, and will include manufacturers and other stakeholders to the process.

Are there particular cost estimating methodologies that are most appropriate for commercial unitary AC and HPs? What role will manufacturers or other interested parties be willing to play in the development of cost estimates?

5.4 Tear-Down Analysis

The use of a component-based engineering analysis or reverse engineering provides useful information including the identification of potential technological paths manufacturers could use to achieve increased equipment energy efficiency. Under tear-down analysis, “off-the-shelf” equipment commercially-available on the market are purchased and physically analyzed, i.e., dismantled, component-by-component to determine what technologies and designs manufacturers employ to increase efficiency. Independent costing methods along with manufacturer and component supplier data can then be used to estimate the costs of the components.

The tear-down analysis will draw on readily available data (provided directly by individual manufacturers through a process approved by the trade organization). In order to satisfy the data requirements, the Department anticipates it would be necessary to:

1) develop a consensus methodology with stakeholders’ input
2) work with the trade organization and individual manufacturers to select a statistically representative sample of products
3) receive key design data from those manufacturers for the sample products
4) undertake tear-downs and production cost analysis
5) verify Department estimates with the individual manufacturers to whom they apply
6) aggregate the results and present them to the trade organization for review
7) revise the analysis and present it to the stakeholders for review and comment

The primary disadvantage of reverse engineering analysis is the time and effort required to analyze “off-the-shelf” equipment. Several models from a diverse range of manufacturers may need to be assessed in order to ensure that an accurate representation of technological paths for increasing efficiency are identified. In addition, since only “off-the-shelf” equipment is being analyzed, new combinations of existing technologies or prototypical designs may not be captured by the analysis, thus, making it difficult to establish maximum technologically feasible designs.

Tear-down analysis is a complementary methodology to whichever of the following engineering approaches is followed. It can serve as verification of costs collected for an efficiency level analysis or provide costs and design options choices for a design option analysis.

Several different commercial unitary AC and HP models will need to be evaluated in order to ensure that all representative technologies for increasing efficiency are identified.

Should the tear-down analysis be used? What are the advantages and disadvantages of this analysis? What guidelines should the Department consider when selecting the number and types of models to be analyzed?

5.5 Outside Regulatory Changes Affecting the Engineering Analysis

In conducting an engineering analysis, there sometimes occur regulatory changes outside of DOE's statutory efficiency standards process that can impact the manufacture of the equipment. Some of these changes can also affect the efficiency of the equipment. The Department will attempt to identify all "outside" issues that can impact the engineering analysis.

The commercial unitary AC and HP industry is currently facing the impending phase-out of HCFC-22, the refrigerant used in almost all the equipment currently being installed in the U.S. The phase-out of HCFC-22 begins in the year 2010 and the industry has responded by conducting in-depth analyses of various HCFC-22 alternatives.

As a result of the analyses conducted to date, two primary candidates have emerged from the field of alternatives; R-410A and R-407C. Both refrigerants have their advantages and disadvantages. Although R-410A shows promise of being able to raise equipment efficiencies, its high volumetric capacity may require systems to be redesigned to handle the significantly higher discharge pressures. R-407C is a virtual drop-in replacement, but may exhibit some efficiency degradation relative to HCFC-22. Thus, it is still uncertain as to what impact the phase-out of HCFC-22 will have on the industry. Namely, how will equipment manufacturer costs and efficiency levels be affected by the phase-out of HCFC-22.

The Department seeks input from stakeholders as to how the impending phase-out of HCFC-22 should be handled in the engineering analysis. Is HCFC-22's phase-out date still far enough in the future to base the analysis on the continued use of HCFC-22? If not, what are the opportunities for a redesign and how will HCFC-22's elimination impact manufacturer costs and equipment efficiency?

Are there any additional "outside" issues that stakeholders are aware of that should be considered by the Department in its analysis of commercial unitary AC and HPs?

5.6 Building Energy Use and Electric Load Shape Characterization

The purpose of the building energy use and load shape characterization analysis is to assess the energy and peak demand savings potential of different equipment efficiencies across the range of commercial building types and climate zones. As part of the building energy use analysis, certain engineering assumptions must be made regarding equipment application, including how the equipment is operated, under what conditions, and as part of what integrated systems.

The Department intends to use computer building energy analysis software in this analysis, as it allows the systematic treatment of interactions among building systems (including building envelope, lighting, and other internal processes) and their operating schedules along with occupancy on building energy use and overall equipment performance. For commercial buildings, state-of-the-art building energy simulation software includes BLAST, DOE-2 and now Energy-Plus. DOE will use one or more of these public-domain building energy models in its analysis.

Representative buildings will be simulated in various climate locations, such as the 11 locations used in the ASHRAE/IESNA Standard 90.1-1999 analyses. Data on new and existing buildings will be used to develop and weight representative building types for modeling. Possible sources include: the Energy Information Administration's (EIA) Commercial Building Energy Consumption Survey (CBECS), Jackson Associates' Market Analysis and Information System (MAISY) database based on CBECS, and utility surveys. Both CBECS and MAISY provide a representative sample of commercial buildings from throughout the United States. Once building prototypes have been defined, whole-building energy simulation software is used in combination with climate data to estimate thermal loads on the commercial unitary AC and HP equipment. Various methods either integral or external to the whole-building energy simulation software will be used to translate equipment thermal loads into equipment energy consumption taking account the part-load operation. Different commercial unitary AC and HP efficiency levels will be input and simulated yielding energy consumption results by building type and climate location.

The Department seeks stakeholder input on the above and other sources of data concerning U.S. commercial building stock characteristics for energy-related modeling purposes. Do you agree with the use of these tools?

The simulations also produce hourly (or sub-hourly) electricity load shapes, which will be used in estimating peak load impacts (described in Section 14) of equipment efficiency improvements above the base case. Together with electricity tariffs this information will generate operating costs for the life-cycle cost analysis in Section 8.

The Department seeks input regarding how to address certain building modeling analysis issues for commercial unitary AC and HPs for determining energy savings.

Economizer Use: Buildings with commercial unitary AC and HPs are likely to use economizers that provide cooling independent of the efficiency of the equipment. *How should the Department include in the analysis the cooling provided by economizers? What assumptions should be made in modeling the equipment regarding the use of, and control strategy applied to, economizers?*

Oversizing: Commercial unitary AC and HPs may be oversized to allow for growth, which affects the runtime, energy performance, and latent heat removal capability. *What assumptions should be made about how equipment is sized in order to address it correctly in the analysis from both an energy and first cost impact?*

Fan Static Pressure: Due to the varied ductwork designs for various commercial buildings the fan static pressures will vary significantly. This will impact energy use and performance of the equipment. *What assumptions should be made regarding typical duct designs in order to effectively account for fan energy use?*

Ventilation Air: Supply fans on commercial unitary AC and HPs generally operate continuously when the building is occupied to provide ventilation air. *How should energy use of the supply fans operating only when ventilation is required (rather than heating or cooling) be excluded from the energy use of the heating and cooling equipment?*

6. Manufacturing Costs

In addition to being used in conjunction with the engineering analysis, manufacturing costs are needed for the manufacturer impact analysis and are used as one means of determining retail prices.

The Department intends to ask manufacturers to participate in the development of cost estimates. The Department prefers to develop its own cost estimates in cooperation with the manufacturers. The Department recognizes that cost estimates developed using the design options approach may need to be supplemented for the manufacturer impact analysis in order to account for different design strategies.

The Department welcomes suggestions and comments concerning the development of manufacturing cost information.

6.1 Characterizing Uncertainty

DOE intends to place a range around the average manufacturing cost of incorporating various design options or achieving various efficiency levels. This cost range will be used in the industry cashflow analysis and could also be utilized to generate retail prices for the consumer life-cycle cost analysis.

The Department proposes that the data collection method incorporate cost estimates bound by a range. For example, manufacturers could provide their most likely point estimate and a range describing the lowest and highest values they consider likely (for each design option or efficiency level). Those values could be used to construct either a triangular or bounded normal distribution for costs. Similar approaches were used recently for the design-option approach (residential water heaters) and the efficiency-level approach (residential clothes washers). The individual manufacturer submittals would be aggregated using a spreadsheet tool and reported back to DOE as percentile values. The entire cost distribution would then be used in the calculation of life-cycle costs. If reverse engineering methodologies are used, ranges can be estimated for each of the reverse engineering model's input parameters (e.g., labor cost, plant size) to determine their effect on the cost estimates.

The Department seeks comment on these approaches to quantifying the uncertainty in our manufacturing cost estimates.

6.2 Variability in Costs between Manufacturers

The Department is committed to assessing the differential impacts of standards on different manufacturers. The detailed sub-group manufacturing impact analysis will entail calculating cashflows separately for each class of manufacturer defined. If appropriate, manufacturer impact analysis will be performed for individual firms.

Manufacturing costs submitted to DOE for appliance standard analyses have demonstrated large variability. The Department prefers using disaggregated cost data from all manufacturers. If the efficiency-level approach is used, disaggregated company-specific cost information developed for the engineering analysis can be used to perform analysis for each manufacturer or manufacturer sub-group.

The method to be used in assessing manufacturer impacts will be the subject of an analysis workshop to be held after publication of the ANOPR. The Department is considering use of the Government Regulatory Impact Model (GRIM), which is in common use for other equipment.

The Department seeks comment on the approach of grouping the manufacturers into sub-groups. What criteria should be used to determine these sub-groups?

6.3 Proprietary Designs

The Department will consider in its analysis all design options that are commercially available or present in a working prototype, including proprietary designs. Proprietary designs will be fully considered in the Department's engineering and economic analyses.

The Department is sensitive to manufacturer concerns regarding proprietary designs and will ensure that provisions are made to maintain the confidentiality of any proprietary data submitted by manufacturers. This information will provide input to the competitive impacts assessment and other economic analyses.

Are there proprietary designs which the Department should consider for commercial unitary AC and HPs? If so, what type of approaches should be used to acquire the cost data necessary for evaluating these designs?

7. Prices

How standards-related manufacturing costs and associated margins are passed through from manufacturers to consumers has an impact on both consumers and manufacturers. Consumer and manufacturer economics are linked. For this reason, retail prices used for the life-cycle cost analysis need to be reconciled with manufacturer costs developed in the engineering analysis. Although the term "retail" is used in this discussion, it is clear that for most of these products there is seldom an observable retail price since the equipment is usually sold as part of an installed Heating Ventilating and Air Conditioning (HVAC) system. In performing an economic analysis to determine whether a more stringent standard is justified, information concerning how the incremental price to the end user changes in response to a change in manufacturing cost is important.

7.1 Retail Prices

At the pre-ANOPR stage, a consumer life-cycle cost curve, based on a distribution of retail prices, is used to perform an initial selection of potential standards levels. Retail prices are needed for the ASHRAE/IESNA Standard 90.1-1999 baseline level, absent new standards, and for all efficiency levels to be considered. Several approaches are possible to obtain these retail prices. Potential approaches include: 1) conducting a survey of existing prices on the market at various points along the distribution chain, to the extent that they can be specifically identified; 2) surveying manufacturers, distributors, and contractors to better understand typical price-setting behavior when basic input costs significantly change; 3) applying various markups (e.g., manufacturer, distributor, and dealer/contractor markups) over variable manufacturing costs.

With regard to the third approach, in June 2000, the Department released a supplemental analysis that employed publicly available data (from the Census Bureau and several trade organizations) to statistically estimate the distributor and dealer markups for residential central AC and HPs (reference: *Estimation of the Distributor/Wholesaler and Dealer/Contractor Markups on Incremental Central AC and HP Costs, US-DOE, June 2000)*. That study concluded that both distributors(/wholesalers) and dealers(/contractors) were likely to pass through changes in equipment costs to a smaller degree than changes in labor and other operating costs. The markups on incremental *equipment* cost were estimated to be 1.09 and 1.27 for distributors and dealers, respectively. Since the distribution channels for small unitary commercial equipment are often similar to this residential equipment, this methodology may be a reasonable starting point for deriving markups for this type of equipment.

The Department believes that there is value in using various assumptions about cost pass-through that will be reflected in price forecast approaches. The output of this analysis can be a table describing retail prices for each possible efficiency level which assumes that each level represents a new minimum efficiency standard. Consistent with the process rule, and building on the estimates generated by the various approaches, new retail prices would be described within a range of uncertainty.

The Department is considering using all the approaches described above to generate estimates of future prices and intends to conduct uncertainty analysis of the range generated. The specific methodologies and preliminary results will be submitted to stakeholders for review.

The above approaches are proposed in an effort to answer the following question: How should the Department collect accurate equipment costs and prices for commercial equipment that is not usually sold in a retail commodity fashion? Are there any nuances we should keep in mind that may distort the results from one approach versus another? The Department welcomes suggestions and comments concerning how estimates of future retail prices can be best developed.

7.2 Manufacturer Prices

Manufacturer prices are used during the industry cash flow phase of the manufacturer impact analysis (Section 13.2). These can be estimated using the same techniques as retail prices, but can also draw directly on information provided by manufacturers or distributors or tracked by organizations such as the U.S. Census Bureau or private market reports.

The Department welcomes suggestions and comments concerning estimates of current and future manufacturer prices.

8. Life-Cycle Cost and Payback Analysis

The effects of increased efficiency standards on a consumer of a product includes a change in operating expense (usually decreased) and a change in purchase price (usually increased). In rulemakings for other products, the Department has analyzed the net effect on consumers by calculating the life-cycle cost using the engineering performance data for energy consumption and equipment retail prices which can be derived in a number of ways (as described in Section 7.1). Inputs to the Life Cycle Cost (LCC) calculation include the installed cost to the consumer (purchase price plus installation cost), operating expenses (energy and maintenance costs), lifetime of the appliance, and a discount rate.

In the ANOPR stage, the life-cycle cost analysis will be conducted using typical values to reflect conditions in the field for product price and life, energy costs, energy usage, and discount rates. The detailed impact calculation, conducted after the ANOPR, will have a comprehensive assessment of impacts on sub-groups of consumers as described in Section 12.

In the ANOPR stage, uncertainty analysis will be conducted on several of the typical values described. During the post-ANOPR consumer analysis (Section 12.), the Department will evaluate additional parameters not included in the pre-ANOPR stage .

Based on the results of the life-cycle cost analysis, DOE will select candidate standard levels for analysis. The range of candidate standard levels will typically include the combination of design options or efficiency levels with the lowest life-cycle cost; as well as other levels yet to be determined by the Department.

In analyzing life-cycle cost, it is important to consider regional impacts due to climate and energy price variability. Because electricity tariffs for commercial customers vary widely and there are no publicly-available centralized sources for these data, the Department has initiated a collection of representative samples of these tariffs for analysis of operating costs. Tariffs will be applied to end-use load-shapes developed from the building energy simulation analysis in Section 5.6 to generate representative operating costs. With this approach, regional comparisons can be made on the operating cost, and in turn life-cycle cost, between different efficiency levels of new equipment.

For commercial unitary AC and unitary HP it will be necessary to determine input values for several variables. The following discusses some of these variables.

Retail Prices: The determination of prices is described in Section 7.1.

Electricity Prices: As discussed above, the Department is considering surveys to establish electricity prices. Projections of future electricity prices for the life-cycle cost analysis will use high and low projections of national average electricity prices to commercial customers. The present Energy Information Administration (EIA) Annual Energy Outlook will be used as the default source of projections for this uncertainty analysis. The Department is considering alternative methods of forecasting future electricity prices including methods for determining marginal electricity rates.

Discount Rate: The calculation of consumer life-cycle costs requires the use of an appropriate discount rate. The discount rate used in such calculations is intended to approximate the cost of capital of those who will make the required investment in higher-efficiency equipment resulting from an amended standard and who would also, presumably, benefit from the resulting savings in energy expenses. Conceptually, the cost of capital reflects all of the funding sources available to the building owner, including debt financing and retained profits (owner's equity). Consequently, the most appropriate discount rate depends on the characteristics of the businesses, institutions, or other parties affected by an amended standard. For the recent commercial ballast rulemaking, the Department used a (real or inflation-adjusted) discount rate of 8%, with sensitivities performed at 4% and 15%. For the commercial unitary AC and HP analysis, the Department anticipates deriving a distribution of consumers' actual financing and opportunity costs to develop appropriate discount rates for the purchase of commercial unitary AC and HP.

Are there recently-conducted empirical studies that have attempted to estimate the distribution of discount rates (or payback criteria) used by building owners in evaluating energy conservation investments or other investments with similar risks?

Maintenance, Service, and Installation Costs: The Department will consider expected changes to maintenance, service, and installation costs for commercial unitary AC and HP, if applicable, such as new curbing required for rooftop equipment in both new and replacement markets.

Tax Impacts: The Department will consider tax implications of equipment purchases.

Lifetime: In the original ASHRAE analysis of these products, a 15-year lifespan was suggested based on estimates for typical unitary equipment. The same 15-year lifespan was used in the recent DOE Screening Analysis and is proposed to be used in this analysis.

Is this an appropriate lifetime for commercial unitary AC and HP? Are there other factors the

9. Shipments

For all candidate standards levels, shipment forecasts are required in order to calculate the national benefits of standards (energy savings and net present value) and to calculate the future cashflows of manufacturers. DOE is considering the use of three approaches to conduct these forecasts including: 1) an approach to derive shipments based on an analysis of key market drivers for the particular product; 2) larger models to consider additional variables (i.e., retirement functions, price elasticities, etc.), and, 3) applying the expert judgment of rulemaking participants.

In order to evaluate the various impacts of candidate energy conservation standards, the Department must develop a base case to compare against. The base case is designed to depict what would happen to energy consumption and costs over time if DOE does not adopt energy conservation standards. The base case is predicted on commercial unitary AC and HP shipments, the mix of efficiencies sold in the absence of standards and how that mix would change over time. To determine the base case, the Department needs data on commercial unitary AC and HP shipments, the market shares of the different efficiency levels offered for each

A method, termed the *accounting model*, based on the accounting of new building construction and historical rates of ownership (saturation rates), is proposed. This method has the distinct advantage of separately accounting for units installed in new construction and existing buildings. More importantly, product saturation rates can be expressed as a function of consumer price and operating cost to capture their impact on future shipments. In expressing saturation rates in this manner, consumer price and operating cost elasticities can be developed to calibrate forecasts to historical shipments. Primary drawbacks of this method include: 1) saturations of units in new and stock buildings must be forecasted; 2) building construction must also be forecasted, although the *Annual Energy Outlook* (AEO*)* and other sources do provide readily available forecasts; and 3) retirement of units must be based upon assumptions regarding lifetimes.

The shipment model used for developing base case and standards cases forecasts can incorporate a variety of features of the product market in order to provide more detailed predictions and accounting. These features may include:

- Market segments: New construction market, early replacement market, regular replacement market, and remodeling market;
- Distinction between purchasers and owners when such a distinction exists;
- Consumer responsiveness to purchase price, operating costs, and business income elasticities;
- Eligible market share and actual saturation rates; and
- Multiple scenarios of efficiency shifts.

In conducting a base case shipments forecast for commercial unitary AC and HP, historical shipments data on the distribution of efficiencies of these equipment are required.

What sources for these data are available?

10. Preliminary National Impacts Analysis

In Section 8.0, the life-cycle cost and energy savings for individual consumers is estimated. In this section, a preliminary assessment of the aggregate impacts at the national level is conducted. Measures of impact to be reported include the net present value of total consumer life-cycle costs, national energy savings, and national employment.

10.1 Inputs to Forecasts

Analyzing impacts of Federal energy-efficiency standards requires a comparison of projected U.S. energy consumption with and without new more stringent standards beyond ASHRAE/IESNA Standard 90.1-1999 which are referred to as base case projections. The forecasts contain projections of unit energy consumption of new equipment, annual equipment shipments and the price of purchased equipment. The derivations of the base case forecasts are discussed in Section 9. Approaches to determining retail prices are described in Section 7.1.

10.2 Calculation of Energy Savings

The Department intends to calculate national energy consumption for each year beginning with the expected effective date of the standards. National energy consumption by fuel type will be calculated for the base case and each candidate standards level. This calculation may be done by one or more alternative approaches, including: 1) the use of a simple spreadsheet to multiply annual shipment forecasts by unit energy savings; 2) the use of commercial sector energy models such as the Electric Power Research Institute's (EPRI) COMMEND, or 3) the Energy Information Administration's National Energy Modeling System (NEMS).

In response to comments by some stakeholders who asked for a simple, transparent model, LBNL has developed the National Energy Savings (NES) spreadsheets. NES is expected to provide a credible stand-alone forecast of national energy savings and net present value for commercial unitary AC and HP.

The Department has prepared spreadsheet models for other products to forecast energy savings and to demonstrate how the growth in efficiency can be accounted for over time. Although these models are specific to each product, their general structure can be applied to commercial unitary AC and HP.

Are there any other models that should be considered as alternatives to these?

10.3 Net Present Value and Payback

The national net present value of the candidate standards levels is calculated in conjunction with the national energy consumption. Annual energy expenditures are calculated from annual energy consumption by incorporating forecasted energy prices. The shipment and energy efficiency distribution forecasts from Section 9 are used. Annual equipment expenditures are calculated from the price per unit times the forecasted shipments. The difference between a base case and a standards case scenario gives the national energy bill savings and increased equipment expenditures in dollars. The difference each year between energy bill savings minus increased equipment expenditures is the net savings (if positive) or net costs (if negative). These annual values are discounted to the present time and summed to give a net present value.

11. Revised Engineering, LCC, and NES Analysis

Based on consideration of the comments received for the ANOPR, DOE will make the necessary changes to the analysis and candidate standards levels. If major changes are required at this stage, stakeholders will be given an opportunity to review the revised analysis. If ASHRAE proposes an addendum to its Standard 90.1-1999 at any point in the rulemaking process, and DOE adopts the efficiency level in the addendum to ASHRAE/IESNA Standard 90.1-1999 efficiency levels, or if DOE determines that the amended ASHRAE/IESNA Standard 90.1 level as revised in October 1999 is appropriate, DOE will not conduct remaining analyses, and will publish a final rule.

12. LCC Sub-group Analysis

In this section, consumer impacts are analyzed by dividing consumers into sub-groups and accounting for variations in key inputs to the LCC analysis, and by inviting consumer and bill-payer participation. A consumer sub-group entails a subset of the population that is likely, for one reason or another, to be impacted disproportionally by new standards. The purpose of a sub-group analysis is to determine the extent of this disproportional impact. DOE will work with stakeholders early in the process to identify any sub-groups for this consideration.

In comparing potential impacts on the different consumer sub-groups, the Department will evaluate variations in regional energy prices, variations in energy use and variations in installation costs that might affect the net present value of a standard to consumer sub-groups. To the extent possible, DOE will obtain estimates of the variability in each input variable and consider this variability in its calculation of consumer impacts. The variability in each input variable and likely sources of information will be discussed with stakeholders.

DOE intends to consider the impact of any new efficiency regulations on consumer sub-groups. In the case of commercial unitary AC and HP products, some possible sub-groups DOE may choose to consider are:

- Owner-occupied vs. tenant-leased buildings.
- Public sector buildings, especially schools, hospitals, etc.

What consumer sub-groups are appropriate?

13. Manufacturer Impact Analysis

The policies outlined in the Department's "process rule" (61 FR 36974, July 15, 1996) called for substantial revisions to the analytical framework to be used in performing manufacturer impact analysis. The Department held a public workshop on March 11 and 12, 1997, to describe and obtain comment on a new generic methodology to be used in performing future manufacturing impact analyses of products covered under the National Appliance Energy Conservation Act of 1987 (NAECA). The Department intends to apply this methodology to other EPCA-related efficiency standards as well, tailoring the methodology for each rule on the basis of stakeholder comments. The analysis of impacts on manufacturers is intended to provide the Department with an assessment of the impacts that may occur on commercial unitary AC and HP manufacturers. In addition to financial impacts, a wide range of quantitative and qualitative effects may occur following adoption of a standard that may require changes to the manufacturing practices for these products. These effects will be identified through interviews with manufacturers and other stakeholders.

13.1 Sources of Information for the Manufacturer Impact Analysis

Many of the analyses described earlier provide important information concerning the manufacturer impact analysis. Information includes financial parameters (Section 3.1), manufacturing costs (Section 6), shipments forecasts (Section 9), and price forecasts (Section 7). This information is supplemented with information gathered during interviews with manufacturers. The interview process has a key role in the manufacturer impact analyses, since it provides an opportunity for interested parties to privately express their views on important issues, allowing confidential or sensitive information to be considered in the rulemaking decision.

The Department and/or contractors will conduct detailed interviews with as many manufacturers as is necessary to gain insight into the range of potential impacts of standards. During the interviews, the Department solicits information on the possible impacts of potential efficiency levels on manufacturing costs, equipment prices, sales, direct employment, capital assets, and industry competitiveness. Both qualitative and quantitative information is valuable. Interviews will be scheduled well in advance in order to provide every opportunity for key individuals to be available for comment. Although a written response to the questionnaire is acceptable, an interactive interview process is preferred because it helps clarify responses and provides the opportunity for additional issues to be identified.

Interview participants will be requested to identify all confidential information provided in writing or orally. All information transmitted will be considered, as appropriate, in DOE's decision-making process. However, confidential information will not be made available in the public record. Participants will also be asked to identify all information they wish included in the public record but that they do not want to have associated with their interview. This information will be incorporated into the public record but reported without attribution.

DOE and/or contractors will collate the completed interview questionnaires and prepare a summary of the major issues and outcomes. The Department will seek comment on the outcome of the interview process.

13.2 Industry Cash Flow Analysis

The Industry Cash Flow Analysis relies primarily upon the Government Regulatory Impact Model (GRIM). The Department uses the GRIM to analyze the financial impacts of more stringent energy efficiency standards on the industry that produces the products covered by the standard.

The GRIM analysis uses a number of factors -- annual expected revenues; manufacturer costs such as costs of sales, selling and general administration costs; taxes; and capital expenditures related to depreciation, new standards, and maintenance -- to arrive at a series of annual cash flows beginning from the announcement of the new standard and continuing for several years after implementation. The results are compared against baseline projections that involve no new standards. The financial impact of new standards is then the difference between the two sets of discounted annual cash flows. Other performance metrics such as return on invested capital are also available from the GRIM.

For discussion purposes, the Department will prepare a list of default financial values to be used in the GRIM industry analysis. These will be calculated by studying publicly available financial statements of commercial unitary AC and HP manufacturers, if available, or statements of companies in similar industries.

13.3 Manufacturer Sub-group Analysis

Using industry "average" cost values is not adequate for assessing differential impacts among sub-groups of manufacturers. Smaller manufacturers, niche players, or manufacturers exhibiting a cost structure that differs largely from the industry average could be more negatively impacted. Ideally, the Department would consider the impact on every firm individually. In highly concentrated industries this may be possible. In industries having numerous participants, the Department uses the results of the industry characterization to group manufacturers exhibiting similar characteristics.

What procedures should we follow when scheduling interviews and requesting information? Is there any value in grouping manufacturers into sub-groups? More generally, what would a well executed sub-group analysis entail?

13.4 Competitive Impacts Assessment

EPCA section 342 (6)(B)(i)(V) directs the Department to consider any lessening of competition that is likely to result from imposition of standards. For these products, the Department must examine whether there is any lessening of competition if a standard is set above the levels established in ASHRAE/IESNA Standard 90.1-1999. It further directs the Attorney General to determine the impacts, if any, of any lessening of competition. DOE will make a determined effort to gather and report firm-specific financial information and impacts. The competitive analysis will focus on assessing the impacts to smaller, yet significant, manufacturers. The assessment will be based on manufacturing cost data and on information collected from interviews with manufacturers. The manufacturer interviews will focus on gathering information that would help in assessing asymmetrical cost increases to some manufacturers, increased proportion of fixed costs potentially increasing business risks, and potential barriers to market entry (proprietary technologies, etc.).

13.5 Cumulative Regulatory Burden

The Department will recognize and seek to mitigate the overlapping effects on manufacturers of amended DOE standards and other regulatory actions affecting the same equipment or companies.

The Department is aware that there are other regulations that could affect this industry.

What regulations or pending regulations should the Department consider?

14. Utility Impacts

To perform the Utility Impacts Analysis, which would include an analysis of both the electric and gas utility industry, the Department is considering using the Energy Information Administration's (EIA) National Energy Modeling System (NEMS). NEMS is a large multi-sectoral partial equilibrium model of the U.S. energy sector that has been developed over several years by the EIA primarily for the purpose of preparing the AEO. NEMS produces a widely recognized baseline forecast for the United States through 2020 and is available in the public domain. Outputs of the utility analysis can parallel results that appear in the latest AEO, with some additions. Typical output includes forecasts of sales, price, and avoided capacity. The entire utility analysis can be conducted as a scenario departing from the latest AEO reference case, and the assumptions in place there can serve as the basic set of assumptions applied.

Should we consider using alternative methods to NEMS for conducting the utility impacts analysis?

15. Environmental Analysis

The standards' analysis tracks three types of energy-related emissions: sulfur dioxide (SO_2), nitrous oxides (NOx) and carbon dioxide (CO_2). These emissions are calculated based on conversion factors developed by EIA for translating natural gas and oil savings into emission reductions.

To perform the Environmental Analysis, the Department will use EIA's NEMS. Outputs of the environmental analysis will mostly parallel results that appear in the latest AEO, with some additions. The entire environmental analysis can be conducted as a modification of the latest AEO, and the assumptions in place there can be the basic set of assumptions applied. For example, the operating characteristics (energy conversion efficiency, emissions rates, etc.) of future electricity generating plant can be exactly those used in the latest AEO.

Carbon emissions are tracked in NEMS by a quite detailed carbon module which should give good results because of its broad coverage of all sectors and inclusion of interactive effects. NEMS also includes a module for SO_2 allowance trading and delivers a forecast of SO_2 allowance prices. It is important to note, however, that accurate simulation of SO_2 trading tends to imply that physical emissions effects will be zero. This fact has caused confusion in the past, and, in prior energy efficiency standards analyses, a simple emission reduction has been reported with the caveat that emissions trading implies that this reduction will unlikely be realized. However, there is an SO_2 benefit from conservation in the form of a lower allowance price, and if big enough to be calculable by NEMS, this value can be reported. NEMS also has an algorithm for estimating NOx emissions from power generation.

The results for the environmental analysis can be in the form of a complete NEMS run. In general, NEMS outputs become the tables of an AEO, and these should provide a good idea of the range of results available. Reported in a NEMS run are NOx and carbon emissions and a resulting SO_2 trading price.

Are there any other environmental factors the Department should consider? If so, what additional analytical methods are appropriate for addressing them?

16. Employment Impacts

Two impacts on employment are possible from standards, direct impacts and indirect impacts. Direct employment impacts would result if standards lead to a change in the number of employees at the plants that produce the covered product, along with its affiliated distribution and service companies. The Department will evaluate direct employment impacts in the manufacturer sub-group analysis described in Section 13.3. Indirect impacts may result from expenditures shifting between goods (substitution effect) and changes in income and overall expenditure levels (income effect) due to standards. The Department will evaluate the combined direct and indirect impacts in the Employment Impacts analysis which will evaluate national job impacts from reallocation of expenditures for purchasing and operating appliances caused by standards.

What methods should be employed to assess employment impacts?